An Open Platform for Digitizing Real World through Sentient Artefact Model

Fahim Kawsar
Waseda University, Japan
Talk Outline

- Motivation
- Scenario
- Sentient Artefact
  - Design Principle
  - Sentient Artefact Development Framework
  - Unification
- Sentient Artefact based location System
- Sentient Artefact based Ad-hoc Micro World Model
- Wrap Up
- Other works
Motivation

- Two primary research assumptions in Pervasive Computing are wrong
  - A Global World Model (Middleware!!) for hosting **ANY** applications
    - Simply Impossible; Looking at History and projecting future with current technology...
  - World Model is not only **LOCATION MODEL**

- Lets stop saying, we are heading towards.....SMART, Context-Aware world, 16 years have already passed looking for that world.
  - Do you want to build your house again?
  - Cost factor!!
Motivation

- Perhaps one feasible way to approach so-called smart environment is utilizing our existing environment, i.e. existing everyday artefacts
  - Indoor Only

- We still do not properly understand or limit the affordability of everyday artefacts.
  - How everyday artefacts can be modified to inject functionality that we expect to have in pervasive environment?

- Once augmented everyday artefacts can monitor and acquire real world information and location dependent ad-hoc federation among these artefacts can provide collection of data models that can be used by applications in that location as long as the access semantics are clarified and unified.
Augmented Artefact and Everyday Life
Sentient Artefact

- Sentient artefacts are everyday objects augmented with various kinds of sensors and actuators that suit their appearance and primary functionalities.

- This augmentation allows these artefacts to provide value added functionalities (so-called context like: state-of-use, environment attributes etc.) beyond their primary roles.
Sentient Artefact

- **Design Principles**
  - Complying with primary roles.
  - No dedicated infrastructure.
  - Natural and implicit interaction.
  - We do not want to give target users a 100 page manual to use a chair.
  - Domain requires self explanatory interaction mechanism.
  - Reusability
  - Communication Capable
Illustrations

- Sentient table provides ambient display service
- Sentient Chair provides state of use information like sitting/not sitting
- Sentient Tray can identify objects it carries
- Sensor augment PDA provides variety of physiological and environmental sensor data
- AwareMirror provides ambient display service
- Sentient Toothbrush provides state of use information and identifies user
- Sentient lamp provides ambient light level with light service
- Sentient Clock can identify Alarm setup timing
- Sentient Door can identify opening/closing event
Development Steps

5-Steps Development Framework based on our experiences

- Step 1: Specify the Required Functionality
- Step 2: Analyze the Artefact’s Usage and Interaction
- Step 3: Clarify Observable Phenomena
- Step 4: List the Candidates of Sensors
- Step 5: Select the Appropriate Sets of Sensor
Our Augmentation Platform

Gumstix running Linux 2.6

Cookie Wireless Sensor Node

Phidget Sensors

400Mhz

RGB color and UV sensor
Vibration Motor
Pressure sensor
Skin resistance sensor
Galvanic skin response
Heart rate sensor
2-axis linear acceleration
Compass
Visible and IR light sensor
10 yen coin
Bluetooth module
Cookie

Sensor Board
2-axis linear acceleration
Compass
Visible and IR light sensor
Main Board
Skin resistance sensor
Galvanic skin response
Heart rate sensor
Bluetooth module
Two Issues

How to determine the sentient artefacts participation in context aware applications in a generic way?

- We must not develop application or scenario dependent sentient artefacts, rather we have to come up with generalized artefacts that can be used in various scenarios and are independent from the applications.

How sentient artefacts location can be acquired?

- It is expensive and to impractical to use dedicated sensor infrastructure for location sensing in domestic environment. We confronted the fact that we need some alternative approaches that can provide the location information in an inexpensive and natural way.
Resolution

- A Profile based approach
- Sentient Artefact based Location System
Artefact Profile

One Artefact With Multiple Roles

Ambient Display

Application A

Proximity Detector

Application B
Multiple Artefacts with Similar Roles
A Profile simply indicates the value added role that an artefact can play considering its affordability.

- Supports loose coupling among artefacts’ functionalities.
- Realistic and appropriate
Many daily life artefacts are immobile in nature and we rarely move them once placed.

We can augment these artefacts with location identifier profile to identify their peer mobile artefacts.
Spreha Location Model

- Implication of Immobile Observation
- Bluetooth Based Implementation
  - Precision Room Level (Ask me if you want to see the evaluation)
Sentient Artefact

- Each Artefact implements one or more generic service profiles. These profiles specify the generic capabilities of an artefact including context sensing.
- Each Artefact is self-contained and can communicate with others to create a federation.
Back to Basics

- World Model

- Location Model
- Activity Model
- Trust Model
- Environment Model
- Personalization Model
- Proximity Model
- Emotional Model

??

??
Back to Basics

Observations

- A model is only needed when there are service consumers at the service location. Service itself might not need the model always.
- Most of the services are local, meaning runs under specific constrains

- Sentient Artefact in conjunction with Users personal Device can provide a few of the models service request basis (WiP)
  - Spontaneous and Ad-hoc federation of artefacts to provide models based on consumers spatial location
  - Micro Scale partial world model
Approach (WiP)

- Sentient Artefact as *Primary Actor*
  - Self Contained, Profile Specific, Independent.

- Artefact Federation as *Primary Action*
  - Service Oriented, Temporal, Spatial and Spontaneous.
  - Service requests initiates the adhoc-federation

- Service-Independent Data Platform as *Primary Relationship*
Approach

- Model Generation
  - Ad-hoc and Spontaneous Initiated by the Applications specifying the requirement. Users spatial location as the key.
  - Location mapping is done through Spreha Concept
Platform: Bird’s Eye View

Service Repository

- Service 1
- Service 2
- Service n

Artefact Repository

- Artefact 1
- Artefact 2
- Artefact n

Model Repository

- Model Definition (Profile Combinations)
- Model
- Location

Service Repository

- Seeks Resource

Artefact Federation

- Generate Subset

Artefacts

- Query Arтеfacts
- Profile
- Location (Updated Periodically)

Data Provider

- Artefact 1
- Artefact n
- Artefact Federation

- Dashed line
Approach

Model

- Model is a higher abstract than context in our assumptions.
  - Model can be user centric (Personalization, Personal Collection Artefacts)
  - Model can be service centric
  - Model can location centric
  - May be more !!!

- Specifies Required Model
  - APIs are provided to abstractly request a model specifying location and models
Approach

Artefact Federation

- Federation is logical grouping artefacts that gives us a specific logical model
- There might be multiple federation existing in the same location for different services with same artefacts.
Approach

‣ Artefact Repository
  ▸ Define and implement Profiles
  ▸ APIs are provided to abstract heterogeneous connectivity (BT, WiFi, RS232 etc.)
  ▸ Deployment Tools are provided. Developers only need to implement the profiles.
Approach

Service Developers

- Define and implement Service
- Specifies Required Model
  - APIs are provided to abstractly request a model specifying location and models
  - Returned Model hides the artefacts federation and provides data required for the service
Current Status

- **Definition of Model**
  - Still investigating how we can provide a generic semantics!

- **Model Access Semantics**
  - Conceptually once the artefact federation is done, we have a data repository specific to service, however currently we are assuming the service developers are aware of the model access semantics for that specific service!
  - This approach needs refinement
Implications

- Service-Centric Artefact Federation
- Less Overhead, Better Data management
- No Physical Data Model, all @ dynamic time.
- Profile based Generalization and Ad-hoc federation together provides a platform accessible from any applications, existing and future ones.
- An Optimistic Approach to solve many middleware issues and increasing inter-operability.
- A Business Model for Future Sentient Artefact Vendors
Wrap Up

- Sentient Artefact
  - Design and Development
  - Implications of Sentient Artefact
  - An optimistic approach to model real world at micro scale.
    - Work In Progress